DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention relates to improvement of an infrared spectroscopy device, especially its continuation light light source.

[0002]

[Description of the Prior Art]In fields, such as spectrometry, since it is needed that the light source of an infrared region has the continuous degree of luminosity in each wave number field, the light source using the energy from a thermal radiator is usually used. Now, as a continuation light light source, thermal radiators, such as a stick of silicon carbide (SiC), a Nichrome wire, and special ceramics, are subjects, for example.

[0003]On the other hand, an improvement is performing and making an infrared spectroscopy device highly efficient all fields from the former. However, a demand of a time is hanging on the ability of a smaller sample and a penetration, or measurement of a sample with bad reflectance to be early measured [how] with high degree of accuracy. As for being contained, for the means for realizing this, it is needless to say that energy radiation from said continuation light light source is made high.

[0004]

[Problem(s) to be Solved by the Invention]However, in the continuation light light source using said thermal radiator, if light source temperature is raised in order to enlarge the energy radiation, since most things used as a raw material of a light source now have the low melting point, it will melt, or will evaporate. On the other hand, if a substance with the high melting point of tungsten etc. is used as a raw material of a light source, it will oxidize in the air.

[0005]Thus, although development of the art in which the infrared light which is high-intensity and was excellent also in stability can be obtained certainly was strongly desired about the continuation light light source in order to perform high precision measurement, the suitable art

which can solve this did not yet exist. This invention is made in view of the technical problem of said conventional technology, and the purpose is to provide the infrared spectroscopy device produced by stabilizing high-intensity infrared light.

[0006]

[Means for Solving the Problem]By taking into consideration time width, repeat frequency, etc. of pulse excitation light with which a millimeter wave and an infrared-radiation element of a semiconductor membrane board are irradiated, as a result of this invention person's repeating examination wholeheartedly about said technical problem, Terahertz radiation which had continuous-spectrum distribution over the wave number range of a request in an infrared wavelength region from a millimeter wave, and continued in time substantially from this millimeter wave and infrared-radiation element by an interaction between an electricity-and-magnetism electric field and an electric dipole of light and a substance is obtained.

[0007]This finds out that it is high-intensity and is the infrared light excellent also in stability as compared with infrared light emitted from a continuation light light source using the conventional thermal radiator, and came to complete this invention. Below, a principle of said terahertz radiation is explained.

[0008]For a millimeter wave and the infrared-radiation element 12 of optical switch element 10 grade of bowtie antenna structure of tangent line-GaAs substrate 9 as shown, for example in drawing 1 at this terahertz radiation, by exposure of the pulse excitation light L11 from the femtosecond laser 14. The terahertz radiation L2 has been obtained by inducing a free carrier of an electron and an electron hole, and carrying out ultra high-speed current abnormal conditions.

[0009]That is, an electric field will be swung if the pulse excitation light L11 is irradiated by a millimeter wave and the infrared-radiation element 12 of bias current impression. If an electric field is swung, the terahertz radiation L2 which had a continuous spectrum in the wave number range specified by time width deltat of the pulse excitation light L11 irradiated by a millimeter wave and the infrared-radiation element 12 will be obtained by swinging current (current) one.

[0010]When a millimeter wave and the infrared-radiation element 12 are irradiated with the pulse excitation light L11 which had time width deltat as shown in drawing 2 (a) here, by an interaction between an electricity-and-magnetism electric field and an electric dipole of light and a substance. From this millimeter wave and infrared-radiation element 12, a time series detecting signal of the terahertz radiation L2 as shown in the figure (b) is acquired. At this time, a spectrum spectrum of this terahertz radiation L2 has continuous-spectrum distribution over the wave number range 0 as shown in the figure (c) - $\text{sigma}_{max}\text{cm}^{-1}$. Here, number of maximum waves sigma_{max} which this terahertz radiation L2 has has the time width delta of the pulse excitation light L11, and a relation of reverse proportion.

[0011]Therefore, when time width of this pulse excitation light L11 is made into 6 femtoseconds, near-infrared wavelength light is contained in the terahertz radiation L2 from a millimeter wave of 0-5556 cm^{-1}. On the other hand, when time width of said pulse excitation light L11 is made into 170 femtoseconds, far-infrared wavelength light is contained in the terahertz radiation L2 from a millimeter wave of 0-196 cm^{-1}.

[0012]By being earlier than a scan speed of a two-beam-interference meter, for example, setting repeat frequency of said pulse excitation light L11 as a value of not less than 1.5 MHz, for example, Since the terahertz radiation L2 generated from said millimeter wave and infrared-radiation element 12 is equal to infrared light which continued in time substantially if it sees from an infrared spectroscopy device of two-beam-interference spectroscopy, it can use, for example as illuminant light of an infrared spectroscopy device of two-beam-interference spectroscopy.

[0013]That is, in order to attain said purpose, an infrared spectroscopy device concerning this invention equips an infrared spectroscopy device of two-beam-interference spectroscopy with the following.

Excitation source.

A millimeter wave and an infrared-radiation element.

A time width setting-out means and a frequency setting means.

Here an infrared spectroscopy device of said two-beam-interference spectroscopy, Halve infrared light emitted from a continuation light light source by a beam splitter, and one side with a horizon glass. A test portion is irradiated with an interference light made by making return light which obtained another side by making it reflect with a scanning mirror compound, and infrared-absorption-spectrum data of this sample is obtained by carrying out the Fourier transform of this irradiation light data detected in a detector.

[0014]Said excitation source generates pulse excitation light of predetermined time width in predetermined repeat frequency. If said pulse excitation light is irradiated with said millimeter wave and infrared-radiation element, it will generate a pulse electromagnetic wave which had continuous-spectrum distribution over a predetermined wave number range in an infrared wavelength region from a millimeter wave by an interaction between an electricity-and-magnetism electric field and an electric dipole of light and a substance.

[0015]Said time width setting-out means sets up time width of said pulse excitation light so that a pulse electromagnetic wave from said millimeter wave and infrared-radiation element may have continuous-spectrum distribution over a predetermined wave number range in an infrared wavelength region from a millimeter wave. Said frequency setting means sets up repeat frequency of said pulse excitation light so that a pulse electromagnetic wave from said millimeter wave and infrared-radiation element may serve as infrared light which continued in time substantially.

[0016]And a pulse electromagnetic wave from said millimeter wave and infrared-radiation element is used as illuminant light of an infrared spectroscopy device of said two-beam-interference spectroscopy. In order to attain said purpose, an infrared spectroscopy device concerning this invention equips an infrared spectroscopy device of distributed spectroscopy with the following.
Excitation source.
A millimeter wave and an infrared-radiation element.
A time width setting-out means and a frequency setting means.

[0017]Here, after an infrared spectroscopy device of said distributed spectroscopy irradiates a test portion with infrared light emitted from a continuation light light source and distributes a penetration thru/or catoptric light of this sample, it obtains infrared-absorption-spectrum data of this sample by decomposing into monochromatic light, and a detector's detecting and carrying out the wave number scan of this monochromatic light. Said excitation source generates pulse excitation light of predetermined time width in predetermined repeat frequency.
[0018]If pulse excitation light from said excitation source is irradiated with said millimeter wave and infrared-radiation element, it will generate a pulse electromagnetic wave which had continuous-spectrum distribution over a predetermined wave number range in an infrared wavelength region from a millimeter wave by an interaction between an electricity-and-magnetism electric field and an electric dipole of light and a substance. Said time width setting-out means sets up time width of said pulse excitation light so that a pulse electromagnetic wave from said millimeter wave and infrared-radiation element may have continuous-spectrum distribution over a predetermined wave number range in an infrared wavelength region from a millimeter wave.
[0019]Said frequency setting means sets up repeat frequency of said pulse excitation light so that a pulse electromagnetic wave from said millimeter wave and infrared-radiation element may serve as infrared light which continued in time substantially. And a pulse electromagnetic wave from said millimeter wave and infrared-radiation element is used as illuminant light of an infrared spectroscopy device of said distributed spectroscopy.
[0020]in addition -- in said infrared spectroscopy device -- an excitation source, a millimeter wave and an infrared-radiation element, and a pulse -- a spectrum -- it is preferred to have a part and a light guide means. Here, said excitation source generates pulse excitation light of said predetermined time width in predetermined repeat frequency. If pulse excitation light from said excitation source is irradiated with said millimeter wave and infrared-radiation element, it will generate a pulse electromagnetic wave which had continuous-spectrum distribution over a predetermined wave number range in an infrared wavelength region from a millimeter wave by an interaction between an electricity-and-magnetism electric field and an electric dipole of light

and a substance.

[0021]said pulse -- a spectrum -- a part irradiates a test portion with a pulse electromagnetic wave from said millimeter wave and infrared-radiation element, detects a penetration of this sample thru/or time resolving data of reflected wave intensity detected in a detector as time series data, and acquires a spectrum spectrum for these time series data by mathematical data processing of Fourier inverse transform. said light guide means -- said pulse -- a spectrum -- the light guide of the pulse electromagnetic wave from a millimeter wave and an infrared-radiation element of attachment in a part is carried out as illuminant light of an infrared spectroscopy device into an optical path of infrared spectroscopy devices, such as said two-beam-interference spectroscopy or distributed spectroscopy.

[0022]In said infrared spectroscopy device, said excitation source is stabilized in pulse excitation light of super-**, and it is preferred for it that they are also femtosecond laser which can be emitted, or an electron beam type oscillator. As this electron beam type oscillator, optical storage rings (PhSR), an orbital synchrotron radiation ring (SOR), etc. are mentioned as an example, for example.

[0023]In said infrared spectroscopy device, said time width setting-out means, It is also preferred to set time width of pulse excitation light generated in said excitation source as 6 femtoseconds or more and 170 femtoseconds or less so that a pulse electromagnetic wave which had continuous-spectrum distribution over a predetermined wave number range in an infrared wavelength region with said millimeter wave and infrared-radiation element from said millimeter wave may occur.

[0024]In said infrared spectroscopy device, said frequency setting means, It is also preferred to set repeat frequency of said pulse excitation light, for example as not less than 1.5 MHz earlier than a scan speed of a two-beam-interference meter so that a pulse electromagnetic wave generated with said millimeter wave and infrared-radiation element may continue in time substantially.

[0025]

[Embodiment of the Invention]Hereafter, one suitable embodiment of this invention is described based on a drawing. The outline composition of the infrared spectroscopy device concerning one embodiment of this invention is shown in drawing 3. In this embodiment, the numerals 100 are added and shown in said drawing 1 and a corresponding portion, and explanation is omitted.

[0026]moreover -- this embodiment -- as an infrared spectroscopy device -- the two-beam-interference spectrometry part 116 and a pulse -- a spectrum -- supposing an infrared spectroscopy device compound [provided with the part 118], this two-beam-interference spectrometry part 116 -- a pulse -- a spectrum -- the case where the light guide of the infrared light emitted to the part 118 from attached millimeter wave and infrared-radiation element 112

is carried out is explained. the compound infrared spectroscopy device 120 shown in the figure -- a pulse -- a spectrum -- the excitation source of attached femtosecond laser 114 grade, and a millimeter wave and an infrared-radiation element 112 are included in the part 118.
[0027]This compound infrared spectroscopy device 120 contains the continuation light light sources 111, such as attached Hg, the interferometer of MP / continuous scan FTIR122 grade, and IR detector 124 grades, such as a bolometer, in the two-beam-interference spectrometry part 116. This compound infrared spectroscopy device 120 contains the computer 126 as a signal processing means.
[0028]It is here and said femtosecond laser 114 is set up by the time width setting-out means of the computer 126 grade in the pulse excitation light L11 of 10 femtoseconds of time width generate repeat frequency, for example at 20 MHz - 50 MHz by the frequency setting means of computer 126 grade.
[0029]If said millimeter wave and infrared-radiation element 112 consist of said tangent line-GaAs substrate bowtie antenna type oscillator, for example and the pulse excitation light L11 from the femtosecond laser 114 is irradiated, In the case of deltat=10 femtosecond, by the interaction between the electricity-and-magnetism electric field and electric dipole of light and a substance, the terahertz radiation L2 which is a pulse electromagnetic wave with continuous-spectrum distribution is generated over wave number range [of 0-3300 cm] $^{-1}$, for example.
[0030]and -- this embodiment -- a pulse -- a spectrum -- the terahertz radiation L2 obtained in the part 118 -- the light guide means of the optical path switching mirror 128 grade for external observation -- a pulse -- a spectrum -- it takes out to the exterior of the part 118 and the light guide is carried out to MP/continuous scan FTIR122 of the two-beam-interference spectrometry part 116. Here said optical path switching mirror 128 for external observation, for example, an actuator (graphic display abbreviation), a drive circuit (graphic display abbreviation), and the control circuit of computer 126 grade -- a pulse -- a spectrum -- when using the part 118, as shown by the dashed line among a figure, the optical path switching mirror 128 for external observation is evacuated out of the optical path of the terahertz radiation L2.
[0031]On the other hand, when using the two-beam-interference spectrometry part 116, as shown by the solid line among a figure, it is constituted so that the optical path switching mirror 128 for external observation may be inserted into the optical path of the terahertz radiation L2. At this embodiment, the terahertz radiation L2 in which the light guide was carried out to MP/continuous scan FTIR122 of the two-beam-interference spectrometry part 116 by the optical path switching mirror 128 for external observation is halved by the beam splitter 134.
[0032]And the sample 140 is irradiated with the interference light L5 made by making it compound, after reflecting L3 with the horizon glass 136 and, reflecting another side L4 with the scanning mirror 138 on the other hand. Photoelectric conversion of the sample penetration

thru/or reflective interference light L6 is received and carried out with the IR detector 124. And the irradiation light data detected with the IR detector 124 is downloaded to the computer 126.
[0033]By carrying out the Fourier transform of this irradiation light data, this computer 126 asks for the infrared-absorption-spectrum data of the sample 140, and outputs it to the display 146 and recorder 148 grade. the compound infrared spectroscopy device 120 concerning this embodiment -- an outline -- it is constituted as mentioned above and the operation is explained below.
[0034]First, the sample 140 is set to the two-beam-interference spectrometry part 116. After setting the sample 140, time width deltat of the pulse excitation light L11 generated by the femtosecond laser 114 via the computer 126, the change of repeat frequency and the optical path switching mirror 128 for external observation, etc. are directed. For example, time width deltat of the pulse excitation light L11 is set as 10 femtoseconds by computer 126. Repeat frequency is set as 20 MHz - 50 MHz, etc.
[0035]And measurement is started based on the directions from the computer 126. That is, although the test portion 140 is irradiated with infrared light and the sample penetration thru/or reflected light data is detected, generally as illuminant light, the infrared light emitted from the thermal radiator of continuation light light source 111 grades, such as Hg, is used. However, in said thermal radiator, in order to perform high precision measurement, when it was going to obtain higher-intensity infrared light, it was difficult to lose stability, and to obtain high-intensity infrared light by being stabilized.
[0036]So, in this invention, the terahertz radiation L2 generated from the millimeter wave and the infrared-radiation element 112 which was excellent also in stability with high-intensity is used as compared with the infrared light emitted from said thermal radiator. For this reason, in this embodiment, if measurement is started based on the directions from the computer 126, a pulse -- a spectrum, if the pulse excitation light L11 is emitted by the high frequency which is 20 MHz - 50 MHz and is irradiated by a millimeter wave and the infrared-radiation element 112 from the femtosecond laser 114 of attachment in the part 118, The free carrier of an electron and an electron hole is induced, and the terahertz radiation L2 is obtained by carrying out ultra high-speed current abnormal conditions.
[0037]Here, in this embodiment, since the time width of the pulse excitation light L11 is set as super-** of 10 femtoseconds, near-infrared wavelength light is contained in the terahertz radiation L2 generated from said millimeter wave and infrared-radiation element 121 from the millimeter wave of wave number range [of 0-3300 cm] $^{-1}$. In this embodiment, since the repeat frequency of said pulse excitation light L11 is set, for example as the high frequency of 20 MHz - 50 MHz, the terahertz radiation L2 generated from a millimeter wave and the infrared-radiation element 112 serves as infrared light which continued in time substantially.
[0038]. In this embodiment, were obtained by devising the time width and repeat frequency of

the pulse excitation light L11 in this way. The terahertz radiation L2 which had a continuous spectrum from the millimeter wave by 0-3300 cm of infrared wavelength region $^{-1}$, and was excellent also in stability with high-intensity is used for infrared absorption measurement of the sample 140 by the two-beam-interference spectrometry part 116. namely, -- this embodiment -- a pulse -- a spectrum -- the terahertz radiation L2 from the oscillator 112 of attachment in the part 118 is taken out outside by the optical path switching mirror 128 for external observation. The light guide of this is carried out to MP/continuous scan FTIR122 of attachment in the two-beam-interference spectrometry part 116.

[0039]And this test section 116 is asked for the infrared-absorption-spectrum data of the sample 140 of installation by performing publicly known signal processing for the irradiation light data detected with the IR detector 124 by computer 126. For this reason, in this embodiment, since it is stabilized and the test portion 140 in MP / continuous scan FTIR122 can be irradiated with higher-intensity infrared light as compared with the conventional continuation light light source 111 which used thermal radiators, such as Hg, good measurement of the signal to noise ratio can be performed.

[0040]this embodiment shows to the figure -- as -- a pulse -- a spectrum -- it being considered as the compound infrared spectroscopy device 120 which combined the part 118 and the two-beam-interference spectrometry part 116, and with directions of computer 126 grade. the optical path switching mirror 128 for external observation -- a pulse -- a spectrum -- or it inserts in the optical path of the terahertz radiation L2 of the part 118 -- or -- only making it evacuate -- a pulse -- a spectrum -- the change of whether the part 118 is used or the two-beam-interference spectrometry part 116 is used is enabled.

[0041]While being able to hold the optical optimum-coordination state of an optical system good by this as compared with what formed these spectrometry parts 116,118 separately independently, simplification of an equipment configuration can be attained. The infrared spectroscopy device of this invention is not limited to said composition, and various modification is possible for it within the limits of the gist of an invention.

[0042]Although the example using the laser beam emitted from this laser 114 with said composition about the modification of the excitation source using the femtosecond laser 114 as an excitation source was explained,It is not limited to this, and other things can be used if excitation of the terahertz radiation L2 which had continuous-spectrum distribution over the wave number range of the request in an infrared region from the millimeter wave and the infrared-radiation element 112 from the millimeter wave is possible.

[0043]For example, it is also very effective to provide electron beam type oscillators, such as optical storage rings (PhSR) and an orbital synchrotron radiation ring (SOR), to impress the ultrashort pulse synchrotron radiation from this PhSR or SOR to a millimeter wave and the infrared-radiation element 112, and to excite the terahertz radiation L2. As long as it can excite

the terahertz radiation L2, it may replace with lights, such as said laser beam, and may be energy etc.

[0044]With said composition, about change of the number range of measured waves, time width deltat of the pulse excitation light L11,For example, although it was set as 10 femtoseconds and the example which obtained the terahertz radiation L2 with continuous-spectrum distribution from the millimeter wave over wave number range [of 0-3300 cm] $^{-1}$ in an infrared wavelength region was explained, By taking into consideration time width deltat of this pulse excitation light L11, number of maximum waves $sigma_{max}$ which the terahertz radiation L2 has can be changed easily. For this reason, it is also possible to use as a light source of the spectrometry part which makes it the number range of measured waves except an infrared region.

[0045]Although said composition explained the example of the continuation light light source of the two-beam-interference spectrometry part 116 about application in various spectrometry parts, for example,It replaces with this two-beam-interference spectrometry part 116 instead of what is restricted to this, for example, of course, can apply also to infrared spectroscopy devices, such as distributed spectroscopy.

[0046]As an infrared spectroscopy device of distributed spectroscopy, a test portion is irradiated with the terahertz radiation from a millimeter wave and an infrared-radiation element, for example, After distributing a penetration thru/or catoptric light of this sample, what obtains the infrared-absorption-spectrum data of this sample is mentioned as an example by decomposing into monochromatic light, and a detector's detecting and carrying out the wave number scan of this monochromatic light.

[0047]a pulse -- a spectrum -- arbitrary things being used as the part 118, if the terahertz radiation L2 which had continuous-spectrum distribution over the wave number range of the request in an infrared region is obtained from a millimeter wave with high-speed repeat frequency, but. For example, what is shown below is more preferred in respect of the versatility mentioned later.

[0048]First, the outline composition is explained. it is shown in drawing 4 -- as -- a pulse -- a spectrum -- when using the part 118, the optical path switching mirror 128 for external observation is evacuated out of the propagation way of the terahertz radiation L2 by computer 126 grade. the pulse shown in the figure -- a spectrum -- the part 118 contains said femtosecond laser 114, said millimeter wave and infrared-radiation element 112, two or more sample sections 152 and 154, two or more detectors 156 and 158, and two or more optical delay means 160 and 162.

[0049]And the terahertz radiation L2 which had continuous-spectrum distribution in it from this millimeter wave and infrared-radiation element 112 over wave number range [of 0-3300 cm] $^{-}$

1 in an infrared wavelength region from the millimeter wave when the pulse excitation light L11 of 10 femtoseconds was irradiated by the oscillator 112 is emitted. The gas sample 153 grade in a gas sample cell is irradiated with said terahertz radiation L2, for example with repeat frequency, such as 20 MHz - 50 MHz. A test portion may be replaced with the gas sample 153, and may install solid sample 155 grade.

[0050]The parallel beam exposure sample section 152 and the convergence light exposure sample section 154 are formed in series all over the propagation way of the terahertz radiation L2 between a millimeter wave and the infrared-radiation element 112, and detector 156 grade by two or more sample sections, i.e., this embodiment, which make multi-sample measurement easy.And it is preferred to establish sample section irradiation optical systems, such as two or more parabolic mirrors 164a-164c, before and after each sample section 152,154 so that it can irradiate with the terahertz radiation L2 from a millimeter wave and the infrared-radiation element 112 in different shape according to a sample.

[0051]For example, it is irradiated with the terahertz radiation L2 from a millimeter wave and the infrared-radiation element 112 by the parallel beam exposure sample section 152 as the parallel beam L2a with the parabolic mirror 164a by arranging direction of the mirror plane of each parabolic mirrors 164a-164c, as shown in the figure. It is condensed by the parabolic mirror 164b, and is irradiated with the terahertz radiation L7a from this parallel beam exposure sample section 152 by the convergence light exposure sample section 154 as convergence light L2b.

[0052]It is condensed by the parabolic mirror 164b, and the light guide of the terahertz radiation L7b from this convergence light exposure sample section 154 is carried out to the detectors 156 and 158. And when measuring gas sample 153 grade, a user puts the gas sample 153 into a gas sample cell, for example, and installs this gas sample cell in the parallel beam exposure sample section 152. A user installs this solid sample 155 grade in the convergence light exposure sample section 154, when replacing with gas sample 153 grade and measuring solid sample 155 grade.

[0053]It becomes possible to cover many samples and measuring mode, and it becomes unnecessary as a result, to exchange optical systems for every sample and measuring mode with one device. That is, since the time and effort which exchanges a different optical system according to a sample or its measuring mode is saved, an optical optimum-coordination state can be held for a long time. Thereby, it can always measure properly. Simplification of an equipment configuration can also be attained.

[0054]And measurement of many samples becomes easy by whether a parallel beam is used or convergence light is used. Thereby, real time (high-speed time resolving) light measurement can be carried out also with which sample of a gas, a fluid, and a solid with the device of 1. Although said composition explained the example which formed the parallel beam exposure

sample section 152 and the convergence light exposure sample section 154 in series, these sample sections 152,154 may be formed in parallel.

[0055]For example, the terahertz radiation L2 from a millimeter wave and the infrared-radiation element 112 is halved by division means, such as a beam splitter, one side is carried out to the parallel beam exposure sample section 152, the light guide of another side is carried out to the convergence light exposure sample section 154, and an each detector can detect the terahertz radiation from each sample section. In this embodiment, it adds, for example to a silicon lens / tangent line-GaAs substrate bowtie antenna element detector 156 as a detector, having formed the femtosecond pulse sampling electrooptics (EO) element detector 158 -- a pulse -- a spectrum -- photoelectric conversion of the terahertz radiation L7 which penetrated the sample 153 (155) of installation is received and carried out to the part 118.

[0056]Said delay means contains the optical delay means 160 for sample measurement which consists of the delay stages 164 which contain the antenna reflector 163 for sample measurement, for example, the actuators 166, such as a stepping motor, the drive circuit 167, a control means of computer 126 grade, etc. The optical delay means 160 for this sample measurement receives light as the sampling pulsed light L12 which directs incorporation of the time resolving data from the detectors 156 and 158, and is carrying out the light guide of the laser beam L1 from the femtosecond laser 114 to the detectors 156 and 158.

[0057]here, as for the computer 126, the pulse excitation light L11 enters into a millimeter wave and the infrared-radiation element 112 once -- so that it may be alike and the two pulses L11 and the delay time difference tau of L12 may change deltat every, Since parallel translation of the antenna reflector 163 of the delay stages 164 is driven and carried out by the actuator 166, delay time difference can be provided in the sampling pulsed light L12 to the pulse excitation light L11.

[0058]It is also preferred to form the optical delay means 162 for time origin adjustment about addition of the delay means for time origin adjustment again in addition to the delay means 160 for said sample measurement.For example, the actuators 172, such as the delay stages 170 and a stepping motor, and the drive circuit 174 containing the antenna reflector 169 for time origin adjustment are provided.

[0059]For this reason, at the delay means 160 for sample measurement to control of the delay time difference of the sampling pulsed light L12 to which it pointed by computer 126 in addition, by using the delay means 162 for time origin adjustment, As compared with the case where only the delay means 160 for sample measurement is established, this delay time difference can be controlled more properly. Thereby, since the light measurement data from the detector 156,158 can be incorporated as directions of the computer 126, this light measurement data becomes what has dramatically high reliability as compared with a thing without such a device.

[0060]And the time resolving data of the intensity of a sample penetration thru/or the reflective terahertz radiation L7 has been obtained by making the computer 126 correspond to each delay time difference, and downloading the time resolving data from the detectors 156 and 158 to it by the sampling pulsed light L12. The computer 126 carried out Fourier inverse transform of the time series data which consist of each incorporated time resolving data, and has obtained infrared-absorption-spectrum data.

[0061]Thus, in this embodiment, the femtosecond laser beam L1 emitted from the femtosecond laser 114 is branched, a light guide is carried out to a millimeter wave and the infrared-radiation element 112 by making one side into the pulse excitation light L11, and the terahertz radiation L2 is generated. this -- a pulse -- a spectrum -- the test portion 153 (155) of installation in the part 118 is irradiated. That light intensity is detected with the detector 156,158, and, as for the terahertz radiation L7 which penetrated this sample (reflection), that detecting signal is supplied to the computer 126.

[0062]With the detector 156,158, the pulse excitation light L11 sticks for a millimeter wave and the infrared-radiation element 112 glaring once here, After the degree of luminosity being made not to be detected and hitting the terahertz radiation L2 to a sample only for a moment [a certain], a certain time delay was set, the detector 156,158 was made one only for a moment, and the instantaneous transmitted light intensity is measured. In case the computer 126 is irradiated [the pulse excitation light L11] once with a time delay by a millimeter wave and the infrared-radiation element 112 at this time, when shifting deltatau every, each time resolving data of terahertz radiation L7 intensity which comes out from a sample has been obtained.

[0063]And the computer 126 asks for the infrared-absorption-spectrum data of this sample the time series data which consist of each time resolving data of the terahertz radiation L7 which penetrated the sample, and makes the display 146 and the recorder 148 output this to them by performing Fourier inverse transform.

[0064]In order to measure the temporal change of the state of a sample about addition of a frequency adjustment means, it excites by irradiating a sample with the terahertz radiation L2, and the temporal change from the point in time is measured.Time resolving ********** can be performed by carrying out the spectrum of the terahertz radiation L7 penetrated thru/or reflected, changing the time interval of the time when this sample is excited, and time for the terahertz radiation L2 to penetrate a sample.

[0065]However, since the repeat frequency of the pulse excitation light L11 is 20 MHz - 50 MHz, for example, in the case of 50 MHz, it will be irradiated with the terahertz radiation L2 by the sample every 20 ns, for example. In measuring the relaxation phenomenon after the sample was excited from the ground state by the terahertz radiation L2, when exciting by the terahertz radiation L2, the problem that a sample is not a ground state arises by the

phenomenon in which an excitation state is longer than 20 ns.

[0066]For this reason, it may be necessary to adjust the repetition time of the pulse excitation light L11 according to the relaxation time of a sample, and the frequency adjustment means 176 of an acoustooptical optical modulator (AOM), an electrooptical modulator (EOM), the reproduction amplification system of laser, etc. is established in this embodiment. Here, said acoustooptical optical modulator (AOM) changes the luminosity of the ultrasonic wave to impress, and modulates the luminosity of the diffracted light.

[0067]By providing this all over the propagation way of the pulse excitation light L11, the repeat frequency of this pulse excitation light L11 can be lowered. Said electrooptical modulator (EOM) is a kind of an optical modulator which changes the amplitude of a polarized light beam, a phase, frequency, a direction, etc. using another Kerr cell and signal-controls electro-optic device. By providing this all over the propagation way of the pulse excitation light L11, the repeat frequency of this pulse excitation light L11 can be lowered.

[0068]By thus, the thing with which this pulse excitation light L11 is irradiated by the frequency adjustment means 176 by lowering the repeat frequency of the pulse excitation light L11 in this embodiment. The repetition time of the terahertz radiation L2 generated from a millimeter wave and the infrared-radiation element 112 can be adjusted according to the relaxation time of a test portion. Thereby, various samples from what has a short life of an excitation state to a long thing can be measured properly.

[0069]In a pulse selected system and an optical-path selected-system book embodiment, in order to obtain higher-intensity terahertz radiation with a millimeter wave and the infrared-radiation element 112, the pulse excitation lights L11, such as a laser beam of high power, are more needed.However, not much, if detector 156 grade is irradiated with the laser beam of high power, etc. as the sampling pulsed light L12, a detector may be damaged.

[0070]So, in this embodiment, form the pulse selected system 178 first and by this pulse selected system 178. the laser beam from which high-intensity electromagnetic waves are acquired and which is 780 nm of high power comparatively, and the grade which does not damage detector 156 grade -- the 1550-nm laser beam of low power is comparatively made selectable. In this embodiment, the optical-path selected system 180 is formed in the upper row of this pulse selected system 178.

[0071]And the light guide of the 1550-nm laser beam can be carried out, for example to a millimeter wave and the infrared-radiation element 112, and detector 156 grade by these pulse selected systems 178 and optical-path selected systems 180. In order to acquire higher-intensity electromagnetic waves, while the high-intensity terahertz radiation L2 is obtained by carrying out the light guide of the 780-nm laser beam to a millimeter wave and the infrared-radiation element 112, and carrying out the light guide of the 1550-nm laser beam to detector 156 grade, Breakage of detector 156 grade, etc. can be prevented certainly.

[0072]Even if it is a case where there is no telling which [of the optical path of the pulse excitation light L11 and the sampling pulsed light L12] becomes long, in excitation light delay stages and this embodiment,The excitation light delay stages 182 may be formed so that the optical path difference may be properly established between this pulse excitation light L11 and sampling pulsed light L12 and predetermined delay time difference can be provided in it according to this optical path difference.
[0073]According to a light chopper book embodiment, the light chopper 184 may be formed all over the propagation way of the laser beam L1 between the optical-path selected system 180, and a millimeter wave and an infrared-radiation element 112.And the laser beam L1 is certainly made into the chopped light of a predetermined time interval by this light chopper 184.
[0074]a pulse -- a spectrum -- the flow of signal processing of a part -- the next -- a pulse -- a spectrum -- the flow of signal processing of the part 118 is explained.Namely, the terahertz radiation L2 generated in this embodiment by irradiating a millimeter wave and the infrared-radiation element 112 with the pulse excitation light L11, The test portion was irradiated and infrared-absorption-spectrum data has been obtained by carrying out Fourier inverse transform of the time series data of the penetration thru/or the reflective terahertz radiation L7.
[0075]For generating of the terahertz radiation L2, here by the exposure of the pulse excitation light L11 as shown in the oscillators 112, such as an optical switch element of a silicon lens / tangent line-GaAs substrate bowtie antenna structure, at drawing 5 (a). The terahertz radiation L2 as shown in the figure (b) has been obtained by inducing the free carrier of an electron and an electron hole, and carrying out ultra high-speed current abnormal conditions.
[0076]And after this terahertz radiation L2 spreads the inside of a sample and acquires that optical property information, it is changed into an electrical signal with the photodetectors 156 and 158. Detection of luminosity E_r (t) of this sample penetration thru/or the reflective terahertz radiation L7, and (the Drawing (c) reference), It is detected as a flow (current) of the career (number: N (t)) excited by the photoconductivity gap by the sampling pulsed light L12 to Thera using the Ruth millimeter wave and the infrared-radiation element, and the same photoconductive switch element.
[0077]current density I (t) -- the convolution of E_r (t) and the excitation career N [several] (t) -- namely [Equation 1]

$$I(\tau) \propto \int_{-\infty}^{+\infty} E_r(t)\, N(t-\tau)\, d\tau$$

It becomes.
[0078]Here, aforementioned tau is a time delay of the sampling pulsed light L12, and detects time dependency E_r (t) of sample penetration (reflection) light intensity as the time base signal

I of current luminosity (tau) by scanning this time delay tau by said optical delay means 160,162. This I (tau) is detected also by the EO element 158 (electrooptics element) which used the nonlinear crystal (TeO_2).

[0079]That is, it is because the detection from high sensitivity detection being expected at high speed according to the EO element 158 rather is preferred as compared with detection according [detection by this EO element 158] to the detectors 156, such as the above-mentioned optical switch element. And the luminosity of a sample penetration thru/or the reflective terahertz radiation L7 is optically sampled extremely at an interval by the predetermined sampling pulsed light L12 (refer to the figure (d)) delayed time deltatau every synchronizing with the pulse excitation light L11 at the time of short.

[0080]For these sampling width delta t seconds, it is set by deltat=1/2pideltasigma to wave number resolution deltasigmacm^{-1} of a light measurement spectrum which measurement is expected and which is demanded. A luminance signal (refer to the figure (e)) of this detected pulse electromagnetic wave is transmitted to the computer 126, and is outputted as a spectrum spectrum as shown in the figure (f) by being changed into wave number space by the inverse Fourier transform processing.

[0081]such a pulse -- a spectrum, since [which can cover a THz field with one set without adjustment of an optical system] it does not come out and repetition time is very as early as 20 MHz - 50 MHz, etc., for example if the part 118 is used, It can measure without receiving most influences of water vapor of the air, etc., and being not only unnecessary but ultra high-speed time resolving light measurement is possible also for a large-scale case for vacuums and an evacuation device.

[0082]It is measurable, without adjusting an optical system with one spectral device for obtaining amplitude and a phase of a refractive index simultaneously independently, and a large spectral region. And so that two or more parallel beam sample sections 152 and convergence light sample sections 154 may be formed in one device in series and it can be irradiated with the terahertz radiation L2 from a millimeter wave and the infrared-radiation element 112 in different shape according to the sample 153 or the sample 155, since direction of a mirror plane is devised, the parabolic mirrors 164a-164c etc. are formed before and after each sample section 152,154 and various samples and measuring modes can be covered with one device -- a general pulse -- a spectrum -- flexibility improves as compared with a case where a part is used.

[0083]In addition to the general optical delay means 160 for sample measurement, as compared with a case where only the delay means 160 for sample measurement is established, control which establishes delay time difference can be more properly performed by forming the optical delay means 162 for time origin adjustment as a delay means which establishes a time delay. In order to lower a repetition of pulse excitation light impressed, for

example to a millimeter wave and the infrared-radiation element 112 as the frequency adjustment means 176 for lowering repeat frequency of the terahertz radiation L2, All over a propagation way of the laser beam L1, repetition time of the terahertz radiation L2 can be adjusted by forming an acoustooptical optical modulator (AOM) etc. according to relaxation time of a test portion.

[0084]Thereby, various samples from what has a short life of an excitation state to a long thing can be measured properly.

Outline composition of a compound infrared spectroscopy device concerning a second embodiment of this invention is shown in second embodiment drawing 6.The numerals 100 are added and shown in said first embodiment and a corresponding portion, and explanation is omitted.

[0085]a compound infrared spectroscopy device shown in the figure -- a pulse -- a spectrum -- the terahertz radiation L2 generated from a millimeter wave and the infrared-radiation element 212 of attachment in the part 218 is once taken out outside by the light guide means 228, and a light guide is carried out to the applied optics system 286. As this applied optics system 286, there are some which perform solid penetration / reflective measurement, optical acoustic measurement, diffuse reflection measurement, total-internal-reflection (ATR) measurement, field air component observation, etc., for example.

[0086]taking out terahertz radiation which penetrated thru/or reflected a sample of installation in this applied optics system 286 from this applied optics system 286 in this embodiment, and passing the light guide means 228 -- again -- a pulse -- a spectrum -- incorporating into an inside of the part 218 -- this pulse -- a spectrum -- members forming of part 218 inside detects. Therefore, while being able to perform good measurement of the signal to noise ratio like said 1st embodiment as compared with a case where the conventional light source is used, various measurement is attained by changing the applied optics system 286 included further outside.

[0087]

[Effect of the Invention]As explained above, according to the infrared spectroscopy device concerning this invention, by irradiating a millimeter wave and an infrared-radiation element with the pulse excitation light of super-** at high speed, The terahertz radiation which had continuous-spectrum distribution over the wave number range of the request in an infrared wavelength region from the millimeter wave, It is made to generate in the state where it continued in time substantially, and since it was considered as things for which many things are used as illuminant light of an infrared spectroscopy device, such as two-beam-interference spectroscopy and distributed spectroscopy, as compared with the infrared light emitted from the continuation light light source using the conventional thermal radiator, high-intensity infrared light can be obtained by being stabilized. Thereby, the infrared absorption of a sample can be measured more to high degree of accuracy. That is, simultaneously with improvement

in the signal to noise ratio, the number field expansion of measured waves can be pulled out. a pulse -- a spectrum -- by taking out outside the terahertz radiation generated with the millimeter wave and the infrared-radiation element of attachment in a part by a light guide means, and using as illuminant light with other infrared spectroscopy devices, such as said two-beam-interference spectroscopy and distributed spectroscopy, As compared with what formed various infrared spectroscopy devices separately independently, the optical optimum-coordination state of an optical system can be held good, and simplification of an equipment configuration can be attained. The measuring beam of the wave number range of desired can be more certainly obtained by establishing a time width setting-out means to set the time width of said pulse excitation light, for example as 6 to 170 femtoseconds, the frequency setting means which sets the repeat frequency of this pulse excitation light as not less than 1.5 MHz, etc.

[Translation done.]